

UNCLASSIFIED

AD 296 356

*Reproduced
by the*

**ARMED SERVICES TECHNICAL INFORMATION AGENCY
ARLINGTON HALL STATION
ARLINGTON 12, VIRGINIA**



UNCLASSIFIED

NOTICE: When government or other drawings, specifications or other data are used for any purpose other than in connection with a definitely related government procurement operation, the U. S. Government thereby incurs no responsibility, nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use or sell any patented invention that may in any way be related thereto.

296356

ASTIA



3-80-62-28

**INSPECTING AND TESTING OF EMBEDDING
MATERIALS AND COMPONENTS
OF ELECTRICAL MODULES
BEFORE, DURING, AND AFTER ASSEMBLY.
A PARTIALLY ANNOTATED BIBLIOGRAPHY**

**SPECIAL BIBLIOGRAPHY
SB-62-43**

NOVEMBER 1962

3-80-62-28

**INSPECTING AND TESTING OF EMBEDDING
MATERIALS AND COMPONENTS
OF ELECTRICAL MODULES
BEFORE, DURING, AND AFTER ASSEMBLY:
A PARTIALLY ANNOTATED BIBLIOGRAPHY**

Compiled by
CHARLIE M. PIERCE

**SPECIAL BIBLIOGRAPHY
SB-62-43**

NOVEMBER 1962

Lockheed

MISSILES & SPACE COMPANY

A GROUP DIVISION OF LOCKHEED AIRCRAFT CORPORATION

SUNNYVALE, CALIFORNIA

ABSTRACT

The control of quality in electronics modules is particularly difficult since the integrated components are totally enclosed within an embedding material. Unfortunately, there are very few references devoted to methodology in this field. This bibliography contains 66 selected references which are related to the inspection and testing of embedding materials and components of modules.

The holdings of the Lockheed Missiles and Space Company Technical Information Center were consulted in the compilation of this bibliography.

The period of coverage dates from 1950 to June 1962.

Availability notices and procurement instructions following the citations are direct quotations of such instructions appearing in the source material announcing that report. The compiler is well aware that many of these agencies' names, addresses and office codes will have changed; however, no attempt has been made to update each of these notices individually.

In citing classified reports, (SECRET TITLE) or (CONFIDENTIAL TITLE) as appropriate, has been used when that classification of the title was indicated on the report. (UNVERIFIED TITLE) has been used when the report was not available to the compiler and it was impossible to verify the report's title and the title's security level.

Classification of classified reports is indicated by abbreviation in upper right top line of bibliographic entry. The classification of the report is given in full, e.g., SECRET REPORT, at the conclusion of the bibliographic data for that report entry.

This selective bibliography has been prepared in response to a specific request and is confined to the limits of that request. No claim is made that this is an exhaustive or critical compilation. The inclusion of any reference to material is not to be construed as an endorsement of the information contained in that material.

TABLE OF CONTENTS

Abstract	iii
Table of Contents	v
Part I - General Topics	1
Part II - Encapsulating Materials	3
Part III - Electronics Components10
Part IV - Weldments and Related Metallurgical Topics	21

Part I

GENERAL TOPICS

1. Cordaro, J.T.
STUDIES ON THE PREVENTION OF CONTAMINATION OF EXTRA-TERRESTRIAL BODIES: BACTERIOLOGIC EXAMINATION OF HERMETICALLY SEALED ELECTRONIC COMPONENTS. Air Force School of Aerospace Medicine, Brooks AFB, Texas. Rept. no. 62-18, Nov 1961.

A description is given of bacteriological techniques for determining the existence of contamination in hermetically sealed electronic components. Both shelf stock components and components for spacecraft were examined using these techniques. 11 of the 161 components tested were contaminated. Of the capacitors, paper and mylar-types were the most likely to be contaminated. Procedures for sterilization are discussed.

2. Earles, D.R.
RELIABILITY APPLICATION AND ANALYSIS GUIDE. Martin Co., Denver, Colo. Rept. no. MI-60-54, rev. 1, July 1961, 1v. ASTIA AD-262 390.

A guide is presented for estimating reliability when a design comparison or a design capability estimate is desired. Procedures and data are included on: (1) reliability, (2) mean-time-to/between-failures, (3) design growth, and (4) preferred component application. Since an estimate of shelf life is desirable in most cases, a table of typical shelf life is included. Reliability specifications, standards, and bulletins are given and worksheets and data sheets are attached. Reliability diagrams are discussed and techniques for the design and development of a reliable piece of electrical equipment are described. The systems outlined for a design analysis are not intended to supplant engineering judgment or experience, but are given to aid the decision-making process.

3. Jorgensen, W.E., Carlson, I.G. and Cros, C.G.

NEL RELIABILITY BIBLIOGRAPHY. SUPPLEMENT

2. Department of Commerce, Washington 25, D.C.

Abstracts are included on failure analysis, general, human engineering, maintenance, mechanical design, and systems and testing topics. The abstracts are numbered in a manner which permits easy interfiling in the basic "NEL Reliability Bibliography".

4. Commonly used specifications and standards

for nondestructive testing. NONDES. TEST.

v. 19, n. 2, p. 138-140, Mar-Apr 1961.

A listing of government and industrial publications relating to specifications and standards used in nondestructive testing.

Part II
ENCAPSULATING MATERIALS

5. Ankward, J. A. and Warfield, R. A.

CONTINUOUS CURRENT MONITORING INSTRUMENTATION FOR ENCAPSULATING RESIN INVESTIGATION. Naval Ordnance Laboratory.

Rept. no. 4247, Feb 1956.

6. Awkward, J. A., Warfield, R. W. and Petree, M. C.

Change in electrical resistivity of some high polymers during isothermal (Polymerization).

J. POLYMER SCI. v. 27, p. 199-205, 1958.

A graphical presentation of resistivity vs. time is included for epoxies at several temperatures. Data obtained from infrared absorption measurements are in agreement with the electrical resistivity tests. The data obtained suggest that relative rates of reaction can be obtained if a correlation between the extent of polymerization and electrical resistivity is known.

7. Anzalone, A. M.

THE APPLICATION OF NONDESTRUCTIVE TESTING TO PLASTICS. Plastics Technical Evaluation Center, Picatinny Arsenal, Dover, N. J.

Plastec note no. 1, July 1961, 39p. ASTIA AD-261 550.

The literature was searched for documents which provide information on nondestructive testing techniques as applied or which are applicable to plastics. In a field of effort in which the past few years have seen marked advances, this search must be considered a status-report. The items located fall roughly into two groups: those techniques which involve ultrasonics and those which do not. This has given basis for the method of presentation, in which Part I covers 25 references on the non-ultrasonic techniques and Part II presents 16 references on the non-ultrasonic approaches. Other related information not available in report form is presented in Part III.

8. Baker, B.

The problem of degassing and sealing faults
of transistor encapsulations. ONDE ELECT.

(FRANCE) v. 41, p. 408-15, Apr 1961. (In French)

The use of an omega type mass spectrometer to identify the partial pressure and composition of gases inside transistor encapsulations at various temperatures is discussed. The tests were conducted on cold-welded encapsulations. Information is also given on the effects of various fabrication techniques upon gas contamination.

9. Birck, M.J., et al

ENGINEERING SERVICES ON TRANSISTORS.

Bell Telephone Labs., Inc., Murray Hill, N.J.

Quarterly progress rept. no. 1, 4 June - 30 Sep 1961.

Rept. no. 6, 31 Dec 1961, 64p. (Contract DA 36-

039-sc-88931, Proj. 3A-99-21-001; Continuation

of Contract DA 36-039-sc-88962) ASTIA AD-271 380.

An investigation of effects of water vapor on thermal aging of multiple diodes in a single encapsulation is discussed. The results of aging several batches of multiple diodes encapsulated with different amounts of water vapor showed that the aging effects are not simple, indicating failure followed by subsequent recovery. This, and other effects, indicate that the interaction of water vapor, residual contamination and the encapsulation itself is complex in that several different mechanisms take place. An improvement in the structure of the GE microwave transistors is proposed. A deposited oxide is used for definition of the collector junction area and for separation of the base and emitter electrodes. Large bonding areas are provided for bonding of leads to the emitter and base electrodes. The essential components of the new structure were electrically satisfactory. A study of the measurement of unilateral gain as a figure of merit for transistors at 1000 mc is reported.

10. Bush, A. J.
Measurement of stresses in cast resins.
MODERN PLASTICS v. 35, n. 6, p. 143-144,
148, 224, Feb 1958.

The testing method described is designed to measure internal stresses in a cylindrical resin casting. The information gained provides a means of selecting the proper resin, filler, the proper cooling rate, and the amount and type of catalyst for a particular need.

11. 0-75% COMPRESSION-DEFLECTION TESTS
ON A FLEXIBLE POLYESTER URETHANE
FOAM, OVER A TEMPERATURE RANGE OF
- 40° F. to 160° F. Hewitt-Robins, Inc., for
Picatinny Arsenal. Report no. 001565, July 1958.

12. Dietz, Hauser, McGarry & Sofer
Ultrasonic waves as a measure of cure. IND.
& ENG. CHEM. v. 48, p. 75, Jan 1956 and
v. 45, p. 2743, 1953.

13. Eller, S. A.
INVESTIGATION OF THE PHYSICAL PROP-
ERTIES OF RESILIENT POLYURETHANE
MATERIALS. Naval Material Laboratory.
Tech. rept. no. 4981-23, (NS-033-200, Subtask 2).

14. Gagne, G. A. and Outwater, J. O.
A PORTABLE ELECTRONIC MOISTURE
DETECTOR FOR REINFORCED PLASTICS.

14. (cont'd) Vermont Univ., Burlington. Technical memo.
no. 172, 15 Oct 1961, 11p. (Contract Nonr-
321901, Proj. NRL 62 RO5 19A) ASTIA AD-266 205.

A new portable instrument is described which is capable of detecting moisture in small concentrations in fiberglass reinforced plastics. Resonant circuits in a balanced bridge network determine empirically the change in permittivity and dissipation factor of the material. A stable crystal-controlled oscillator powers the bridge and measurement consists of placing a probe against the material, readjusting the bridge and noting the imbalance.

15. Gutowsky, H. S., Bernheim, R. A. and Tarkow, H.
Measurement of internal stresses by radio-
frequency spectroscopy. J. POLYMER SCIENCE
v. XLIV, n. 143, p. 143-148, May 1960.

A description of a method for measuring internal stresses developed within resins as they cure. This method takes advantage of the effects of pressure on the pure quadrupole resonance frequency of Cl^{35} nuclei (in potassium chlorate) and Cu^{63} (in cuprous oxide). Since Cu_2O is easily powdered, the Cu^{63} is more easily used. The Cu resonance has a dv/dP which is independent of temperature but the absorption line is very broad. KClO_3 has a very narrow chlorine resonance line but its dv/dP is very small and temperature dependent. The technique described involves the dispersion of the Cu_2O in Epon 828. The nuclei are oriented by the electric field gradients present in the crystalline solids and therefore, no magnet is required. The sample is placed inside the tank circuit coil of a modulated frequency marginal oscillator. The oscillator is tuned so that the resonance line is traversed by the frequency modulation and the change in oscillational level produced by absorption is detected, amplified, and displayed on an oscilloscope.

16. Hastings, C. H. and Grund, M. V.
Radiographic inspection of reinforced plastics
and resin-ceramic composites. NONDESTRUCTIVE
TESTING v. 19, n. 5, p. 347-51, Sep-Oct
1961.

Discusses the development of radiographic test procedures for reinforced plastics and resin-ceramic materials. Tests were made to determine characteristics such as density gradients and soundness. Results of the initial work indicates that this test is

16. (cont'd) of little value for the evaluation of reinforced plastics but of extreme importance for the resin-ceramic materials. The test procedures may be applied to process control and production inspection. Radiographics of representative discontinuities are included and discussed.

17. Heise, R. E., Jr.
RESIDUAL AND THERMAL STRESSES IN POTTING
RESINS AND THE DEVELOPMENT OF STRAIN
GAGE INSTRUMENTATION FOR THEIR DETER-
MINATION. Naval Ordnance Laboratory, White
Oak, Md. Rept. no. NAVORD 5767, 29 Aug 1958.
18. INTERNATIONAL SYMPOSIUM ON PLASTICS
TESTING AND STANDARDIZATION. American
Society for Testing Materials, Philadelphia, Pa.
ASTM Special Technical Publication No. 247,
272p.

The majority of the papers are concerned with test methods and nomenclature, equipment, and the results of the tests. Topics include: shear tests, impact tests, flow testers, softening point tests, infrared spectroscopy, and x-ray diffraction and scattering tests.

19. Morelli, F. A.
TESTING OF RESINS AND POTTING COMPOUNDS
FOR SPOROCIDAL ACTIVITY. JPL Research
Summary no. 36-12, p. 14-16, Oct-Dec 1961.

A small number of resin systems exhibit sporocidal activity. 20 resin systems were tested using the spores of *B. subtilis* spores. The resins which exhibited definite sporocidal action are: ECKO-1216 (Catalyst 9), Armstrong A₂ (activator E), Epon 815 (Catalyst TETA), and Epon 828/Epocast 985/10% Ethylene Imine^a in methanol. A description of the equipment and techniques used are given. A tabular presentation of the results is included.

20. Resnick, I.
 REPORT OF INVESTIGATION ON NONDESTRUCTIVE TESTS FOR FOAMED-IN-PLACE RESINS.
 Material Lab., New York Naval Shipyard, Brooklyn.
 Progress rept. no. 1; Lab. Proj. 6193, 13 Sep 1961,
 18p. ASTIA AD-267 118.

Nondestructive test methods for expanded plastics were studied with the objective of developing a technique for detection of flaws in large sections. Results of an experimental survey using ultrasonic, dielectric, infrared, thermal conductivity, x-ray and neutron absorption techniques are reported. Comments on these and other methods are included. At present, the neutron absorption, thermal conductivity and infrared techniques appear to be more promising than the others.

21. Sampson, R. N. and Lesnich, J. P.
 STRAIN GAUGE EVALUATION OF CASTING RESINS. 14th Annual Conference, Society of Plastics Engineers, Detroit. Jan 1958.
22. Sampson, R. N. and Lesnich, J. P.
 Evaluation of casting resins employing strain gauge techniques. MODERN PLASTICS v. 35, n. 6, p. 150, 153, 225-226, Feb 1958.

A description of a technique for quantitatively determining the stresses produced on an embedded component by a casting resin. The results of the test are useful in providing information on the selection and processing of casting resins and for maintaining quality control.

23. Vial, T. M. and Blaich, C. F.
 Faster methods of physical testing (for urethane compounds). RUBBER AGE v. 91, n. 2, p. 264-268, May 1962.

23. (cont'd) Describes a testing program for the evaluation of high performance elastomer samples in a much shorter time. The series of procedures used consist of modifications of standard testing methods which provide a maximum amount of information with relatively few tests.

24. Warfield, R. W.
TEST METHODS FOR THE STUDY OF THE PROPERTIES OF CASTING RESINS. Naval Ordnance Laboratory. Report no. 6029, Mar 1958.
25. Warfield, R. W. and Petree, M. C.
THE USE OF ELECTRIC RESISTIVITY IN THE STUDY OF THE POLYMERIZATION OF THERMO-SETTING POLYMERS. J. Polymer Sci. v. 37, p. 305-8, 1959.

Part III
ELECTRONICS COMPONENTS

26. Alameda, J.M.
The agents responsible for the deterioration
of electronic equipment. (Los agentes responsables
de la degradacion de equipos electronicos.)
REVISTA DE CIENCIA APLICADA v. 14, n. 73,
p. 121-129, Mar-Apr 1960. (In Spanish)

A series of rapid tests for determining the effects of mechanical, climatic, and physiochemical agents of deterioration on electrical equipment and components.

27. Anderson, L.J. and Posakony, G.J.
INVESTIGATION OF METHODS FOR DETER-
MINING ACTUAL FLAW SIZE IN MATERIALS
BY NONDESTRUCTIVE ULTRASONIC MEANS.
Automation Industries, Inc., Boulder, Colo.
Rept. for 15 May 1960 - 1 May 1961 on Materials
Application. Rept. no. ASD TR 61-205, Sep 1961,
53p. (Contract AF 33(616)7279, Proj. 7381)
ASTIA AD-268 894.

Applied research was conducted to determine methods of analyzing ultrasonic reflections from material discontinuities; and further, to develop breadboard prototype electronic instrumentation to produce a 3-dimensional isometric projection of internal discontinuities in their true perspective using a single transducer system. Emphasis was on development of a new concept of presentation of data. This new concept involved display of information as a function of the sound beam properties propagated in

27. (cont'd) the material. A special transducer manipulator was designed to provide the required sound beam action to view internal discontinuities from all angles. This contract has proven the practicality of using a single oscillating transducer scanning system.

28. Ashby, A. T.

INSTRUMENTATION AND MEASUREMENT

TECHNIQUES STUDY. Armour Research

Foundation, Chicago, Ill. Quarterly rept.

no. 10, 1 May - 31 July 1961. Rept. no.

ARF 5112-30, 31 July 1961, 70p. (Contract

no. DA 36-039-sc-78269, Proj. 3G89-01-021-01)

ASTIA AD-265 836.

Work was continued in several areas of investigation intended to advance the state-of-the-art of electrical measurements. A square wave technique for isolating faulty components in conventionally-wired or printed circuitry without the need of unsoldering was implemented and is described. A modified sawtooth signal shows promise of isolating faulty semiconductor devices in-the-circuit. A survey of recording and readout techniques other than the normally employed magnetic devices is presented. This discussion outlines the problem areas in thermoplastic recording Kerr magneto-optic and electron beam readout devices. Techniques for locating faults in long-line spiral-four systems are discussed. Two correlation techniques are discussed, and a breadboard impedance-phase angle measuring device is described. An investigation of the properties of spiral-four cable is also described.

29. Automated quality control. ELECTRONIC/

ELECTROMECH. PRODUCTION v. 1, p. 24-

27, Dec 1961.

Ten G. E. programmed testing systems are outlined for automatically testing components and control production. Cost advantages are emphasized.

30. **AUTOMATIC TEST EQUIPMENT STUDY**
EXTENSION. General Dynamics/Electronics,
 Rochester, N.Y. Final engineering rept.
 1961, 308p. (Contract AF 33(604)32036; Continuation of Contract AF 33(604)28541) ASTIA AD-268
 323.

Work was performed on a study program determining the detail requirements for an automatic test system for testing of airborne electronic equipment. Presented is the technical information required to pursue an equipment development program of the versatile automatic test system utilizing a building block concept of design. The system will have capabilities of performing fault isolation on over 35 airborne electronic systems (not including WRAMA equipments) including piece part fault location on various subassemblies of these systems. The automatic test system is not limited to the 35 airborne electronics systems studied in detail, but has an estimated capability of checking 80% (exclusive of special cables required) of electronic equipment in the Air Force Inventory. Various problems associated with implementing an automated test facility were considered and studied. Those considered were logistic support, planning, scheduling and changing skill levels. Also considered were economic advantages gained due to expected increase in MTBF of the airborne electronic equipment due to exhaustive testing possible through use of automation.

31. **Barsam, F.M.**
MARGINAL CHECKING TECHNIQUES
STUDY. Burroughs Corp., Paoli, Pa.
 Final rept. Rept. no. RADC TR 61-83,
 Reference no. 681-61-336-L, Feb 1961, 341p.
 (Contract AF 30(602)2163, Proj. 5519) ASTIA
 AD-260 692.

A survey, study, and development program on marginal checking techniques was conducted. A theory of margin checking has been developed and is presented herein. On the basis of the theory the conclusion is reached that there are two basic approaches to measuring margins-to-failure in different classes of circuits. These approaches are called indirect margin checking (IMC) and direct margin checking (DMC). The technique generally known as marginal checking is shown to be of the latter category.

31. (cont'd) An advanced margin checking system was developed and proposed for use in digital equipment of the complexity of Atlas or SAGE. The concept is predominantly theoretical and not fully substantiated by hardware experience. Six IMC/DMG margin checking techniques, developed as an important part of this program, are described and evaluated. The results of the state-of-the-art survey are summarized, discussed, and analyzed. Abstracts are included of reports made available on the subject of marginal checking.

32. Belt, W.

Ultra-reliability. ELECTRONIC/ELECTROMECH.

PRODUCTION v. 1, p. 22-23, Dec 1961.

A discussion of a testing program involving sampling techniques using potentiometers is discussed.

33. DiLauro, S. and Kiefer, F.P.

Radiographic and polarographic testing of electronic

components. NONDESTRUCTIVE TESTING v. 19,

n. 4, p. 261-263, July-Aug 1961.

Describes a nondestructive testing procedure for inspecting mercury-wetted relays. The use of x-ray analysis permits the location of leaky vials and the detection of improper assemblies. Polarographic techniques were used to make in-process measurements of glass vial pressurization. These techniques in conjunction with destructive testing techniques gave information on the true causes of failure, thereby providing information on how to improve fabrication procedures.

34. Frundt, H.J.

THE UNRELIABILITY OF ELECTRONIC

APPARATUS AND ITS CAUSES. (Die unzuverlaes-
sigkeit elektronischer geraete und ihre ursachen.)

Ministry of Aviation, Gt. Brit. Nov 1961, 7p.

ASTIA AD-271 426. (Trans. no. TIL/T.5254 of

N. T. Z. v. 13, p. 524-528, 1960, Germany).

34. (cont'd) Contents: Failure characteristics of apparatus; Series and parallel connection; Influence of components on the reliability of apparatus; Increasing reliability; Determination of rates of failure; Present quality of components; Quality desirable in components.

35. GENERAL USAGE ASSEMBLIES FOR NAVY
ELECTRONIC EQUIPMENT. Vitro Labs.,
West Orange, N.J. Final rept. Aug 1959 -
June 1961. Rept. no. VL-2062-7-0, 31 July 1961,
25p. (Contract NObsr-72538) ASTIA AD-266 203.

Life testing of transistorized general usage assemblies has given invaluable data for the determination of assembly life, as well as validating reliability prediction techniques derived by these laboratories in a previous study program. Life testing of certain assembly types that underwent extensive environmental tests provided some insight into techniques for accelerated testing of electronic subassemblies. It was revealed that electronic assemblies can be expected to deliver adequate performance for an average period of 10 times longer under laboratory conditions than under normal in-use field conditions. Also, the life of an assembly can be expected to decrease by a factor of 64 (on the average) when that assembly has been exposed to standard, military-approved, environmental tests. A method of deriving meaningful accelerated tests for electronic assemblies is suggested by these observations.

36. Green, W. B.
A fatigue-free silicon device structure.
TRANS., AMER. INST. ELECT. ENGRS. I. v. 80,
p. 186-91, 1961

A discussion of equipment and tests used to determine the nature of fatigue failure of soft-soldered silicon diodes. The test involves the application of controlled amounts of overvoltage and overloads in both the forward and reverse directions at monitored temperature. Quantitative descriptions of the failures are given in terms of the thermal expansion coefficients of dissimilar metals, junction dimensions, elevated temperatures, etc. Methods of eliminating failures are discussed.

37. Hirsh, S. J.
 TESTING ADHESION OF PRINTED WIRING
 PATTERNS. Frankford Arsenal, Philadelphia, Pa.
 Engineering rept. no. 6220-4, Aug 1961, 20p.
 ASTIA AD-266 490L.

Information is included on tests and test methods.

38. Jackson, T. A.
 INSTRUMENTATION AND MEASUREMENT
 TECHNIQUES STUDY. Armour Research Founda-
 tion, Chicago, Ill. Quarterly rept. no. 11,
 1 Aug - 31 Oct 1961. Fept. no. ARF 5112-Q11,
 31 Oct 1961, 21p. (Contract DA 36-039-sc-78269,
 Proj. 3G89-01-021-01) ASTIA AD-268 971.

A technique for isolating a circuit fault in a printed circuit board is described. A current transformer permits current measurement in any one of several parallel branches. The behavior of a spiral-four line containing repeaters, and having a fault at some point is discussed. Pulse reflection fault location techniques are examined. Presently known methods of SSB signal generation are outlined, and associated problems are discussed. An approach is selected which should minimize intermodulation distortion. The proposed system uses Hall-effect multipliers in the phase-shift unit, and breadboarding of the system is partially complete.

39. Jervis, E. R.
 STUDY OF FACTORS AFFECTING SYSTEM
 RELIABILITY. ARINC Research Corp.,
 Washington, D. C. Final rept. Pub. no. 148-
 2-248, 17 July 1961, 35p. (Contract SD-51-3)
 ASTIA AD-272 191.

39. (Cont'd) The use of failure-prediction techniques for electronic equipment is broadly recognized as a valuable tool for establishing the feasibility of novel applications as well as for estimating the reliability and availability of more conventional equipments. The importance of foreseeing the behavior of electronic devices in future applications is so great that prediction results are accepted even if the accuracy is poor or the confidence interval for the prediction is extremely broad. A method of failure data collection for reliability-prediction purposes is outlined which utilizes a computer program so that all required items of information can be automatically fed into the process of data accumulation and the required failure rate information can be obtained from the computer with a minimum of effort.

40. Kinney, M.
A BIBLIOGRAPHY OF X-RAY STUDIES OF
ELECTRONIC COMPONENTS. Autonetics,
Downey, Calif. Rept. no. EM-7274, 20 Sep 1961,
53p. ASTIA AD-265 064.

Radiography is used by industry as one of the tools for nondestructive inspection and testing. It is a valuable method because it discloses even minute flaws without impairment of the object. This bibliography of 166 references is arranged alphabetically by title and covers the years 1944 through 1961. An author index and a combined periodical and source index follow the references.

41. PARTS RELIABILITY IMPROVEMENT PROGRAM
REPORT - ST4180. A.C. Spark Plug Div., General
Motors Corp., Milwaukee, Wis. Rept. no. 20-V-
233; IDEP rept. no. 752.50.60.40-A4-05, Sep 1961,
40p. (In cooperation with Transitron Electronic
Corp., Wakefield, Mass.) ASTIA AD-273 949.

Information is included on testing.

42. Peach, N.
New tests for electronic systems. POWER v. 106,
p. 35-39, Jan 1962.

Non-destructive testing using electric test methods is discussed.

43. Plaskett, V. A.

WELD EVALUATION - HIGH SPEED MOVIES.

Lockheed Aircraft Corp. , Missiles and Space

Division. Rept. no. MRI 270-05, Mar 1961, 9p.

Color movies were taken to show the physical action of electrodes and materials during the welding of electronic components.

44. Seltzer, D. D.

Correlation studies between destructive and
nondestructive tests of electronic components.

NONDESTRUCTIVE TESTING v. 19, n. 4,

p. 243-51, July-Aug 1961.

A description of nondestructive test methods and their applications. Methods studied include x-ray, ultrasonics, optical micrometry, stereomicroscopy, capillary flow analysis, and visual examination. Components and materials tested include soldered contacts, mercury-wetted contact relays, pyrotechnic components, electroplated circuit boards, and lead zirconate titanate transducers. Studies were also made on the solderability of silver-plated surfaces of electrical components contaminated by oxides and sulfides.

45. Tobin, H. G.

INSTRUMENTATION AND MEASUREMENT

TECHNIQUES STUDY. Armour Research

Foundation, Chicago, Ill. Quarterly rept.

no. 9 for 1 Feb - 30 Apr 1961. Rept. no. ARF

5112-27, 30 Apr 1961, 50p. (Contact DA 36-

039-sc-78269) ASTIA AD-259 926.

A square-wave technique for isolating faulty components in conventionally-wired or printed circuitry without the need of unsoldering is presented. Preliminary study indicates that the technique may enable general identification of the type of circuit fault involved. Another technique to assist in faulty component identification utilizes a low voltage source to permit impedance measurements to be made in transistor or

45. (Cont'd) diode circuitry. A combination of the 2 techniques may enable fairly rapid isolation of a faulty component to be made. Techniques for locating faults in long-line spiral-four and open wire systems were investigated. One promising approach involves measuring the phase angle of the input impedance of the line, and comparing this data with previously measured or calculated information. A survey of commercial ac voltage standards was made in order to determine the capabilities of such units for providing a source for voltmeter calibration. A discussion of the capabilities and limitations of magnetic recording in the area of automatic testing is presented.

46. Schilling, E. G.
The challenge of visual inspection in the
electronics industry. INDUS. QUALITY
CONTROL v. 18, n. 2, 12-15, Aug 1961.

A discussion of inspecting personnel qualifications, visual inspection techniques, and the attainment of uniformity in inspecting.

47. TEST METHODS FOR ELECTRONIC AND
ELECTRICAL COMPONENT PARTS.
Military Standard MIL-STD-202A, Change
Notice 2, 28 Aug 1958.

48. Vogt, J. J., et al
Some aspects of metals joining for electron
tube applications. In ADVANCES IN
ELECTRON TUBE TECHNIQUES, FIFTH U. S.
NATIONAL CONFERENCE, PROCEEDINGS,
Sep 1960, p. 21-30. New York, Pergamon
Press, 1961.

A section is included on weldments of Ni to Ni and Ni to Mo. Weld characteristics are determined by examination of as-welded cross-wires and weld cross sections. Strength tests are also used. 27 references are included.

49. Warr, R. E. , Applegate, F. and Andrews, T.

PART REJECTION ANALYSIS. Advanced

Electronics Center, General Electric Co. ,

Ithaca, N. Y. Rept. on Factors Affecting the

Reliability of Electronic Equipment.

Rept. no. WADD TR 60-516, Sep 1960, 18p.

(Contract AF 33(616)7626, Proj. 4156)

ASTIA AD-268 098.

A portion of the reliability study and investigation of aeronautical electronic equipment is given. The data for the study were selected from two quality control operations, one a manufacturer producing a number of different airborne electronic equipments and the other a manufacturer producing a single missile guidance equipment. Data were analyzed in terms of vendor quality, part type quality, and the nature of the defects.

50. Warr, R. E. and Andrews, T.

CIRCUIT CLASSIFICATION AND AVALUATION.

Advanced Electronics Center, General Electric

Co. , Ithaca, N. Y. Rept. on Factors Affecting

the Reliability of Electronic Equipment. Rept.

no. WADD TR 60-848, Jan 1961, 68p. (Contracts

AF 33(616)6726, Proj. 4156 and AF 33(616)6725)

ASTIA AD-266 718.

A circuit classification method is presented that would make it possible to obtain uniform circuit failure data. In addition, use of the classification method would aid in the selection of reliable circuits for equipment development programs. Efforts were also concerned with the problem of evaluating circuits from the standpoint of reliability. A general design procedure is presented to aid in the selection and evaluation of circuits for reliable equipment applications.

51. Warr, R. E. , Bozovich, J. and Andrews, T.
RELIABILITY OF MODULAR ASSEMBLIES.
 Advanced Electronics Center, General Electric
 Co. , Ithaca, N. Y. Rept. on Factors Affecting
 the Reliability of Electronic Equipment. Rept.
 no. WADD TR 60-515, July 1961, 25p. (Contract
 AF 33(616)6726, Proj. 4156) ASTIA AD-267 146.

An investigation was made on the reliability of automatically assembled modules used in commercial and military equipment. The objective was to compare the reliability of such a modular assembly with the reliability of a similar group of parts assembled in a conventional manner. The modular type chosen for the investigation was the Tinkertoy stacked ceramic-wafer module. A statistical comparison of the electronic reliability of a military equipment (AN/SSQ-23 sonobouy) partially utilizing Tinkertoy type modules and an identical equipment utilizing conventional assembly methods was performed. Additional environmental test data on other modular equipment is presented as supporting evidence to the statistical conclusions. Theoretical considerations related to the reasons for any change in reliability are also presented. Possible manufacturing cost implications for comparative modular and conventional assemblies are indicated by the operating experience of manufacturers using, or considering, Tinkertoy type modules.

52. X-ray teams with better welding for sub-
 miniature electronic tubes. **AMER. MACHINIST**
 v. 103, p. 95, 5 Oct 1959.
53. Zinke, W. L. and Tepper, C.
A PROGRAM TO DEVELOP A SYSTEM FOR
THE INSPECTION OF SOLDERED ELECTRICAL
JOINTS. Eastman Kodak Co. , Apparatus and
 Optical Div. , Rochester, N. Y. Third Quarterly
 Report of Progress Covering the Period 5 Sep 1961 -
 4 Jan 1962. Rept. no. EK/ARD ED-759, 16 Mar 1962,
 109p. (Contract DA-30-069-507-ORD-3252)

Part IV
WELDMENTS AND RELATED METALLURGICAL TOPICS

54. American Society for Testing Materials, Philadelphia, Pa.
ASTM STANDARDS, 1959 SUPPLEMENT.
PT. 3. METHODS OF TESTING METALS
(EXCEPT CHEMICAL ANALYSIS). 106p.

Methods include tests for determining mechanical properties, temperature effects, corrosion, electrical and magnetic properties, nondestructive tests, and sampling techniques.

55. Bracewell, L.
Defects in welding – their cause and detection.
AUSTRALASIAN ENGINEER p. 87, 89, Dec 1960.

Information is included on the relation of voltage, current, welding speed, weld preparation, electrode composition, and impurities to welding defects.

56. Cockett, G.H. and Phelan, H.K.
A SIMPLE TECHNIQUE FOR ELECTRON
MICROSCOPE SEQUENTIAL STUDIES ON
PRESELECTED METALLURGICAL FEATURES.
Armament Research and Development Establishment,
Gt. Britain. ARDE Memo. no. (MX) 51/61,
Oct 1961, 15p. ASTIA AD-266 433.

Constructional details are given for a simple attachment which when fitted to a metallurgical microscope enables sequential electron microscope studies of preselected areas to be made. An example of its application to the chemical smoothing of steel is given.

57. Jazek, J.
Application of electron microscopy. A simple extraction replica for the study of fine grain phases. METAL TREATMENT AND DROP FORGING v. 27, p. 19-27, Jan 1960.

A description is given for a method of preparing specimens for the purpose of disclosing precipitates by electron micrography.

58. Kaufman, W. J.
Nondestructive testing of weldments.
LASTECHNIEK v. 26, p. 153-165, Sep 1960.
(In Dutch)

Methods of inspection include the use of ultrasonics, x-rays, electron beams, and the radiation from radon.

59. Lewis, R. K. and Norton, J. T.
INFRARED DETECTION OF WELD DEFECTS.
Advanced Metals Research Corp., Somerville, Mass. Final rept. on Infrared Detection Non-destructive Testing Applications. Rept. no. WAL 550/1-1, 31 June 1961, 30p. (Contract DA 19-020-ORD-5228, Proj. TB4-004) ASTIA AD-263 983.

In the first phase of the program an electrical analog was used to simulate the surface temperature distribution in plates containing various types of defects when the plate was subjected to a known temperature gradient. The resulting temperature field patterns were analyzed quantitatively to give temperature differences due to the presence of the defect. This information permits a calculation of the minimum size of detectable defects when the performance of the temperature sensing device is known. The second phase of the program involved designing, constructing, and testing a device

59. (cont'd) employing infrared techniques for measuring very small temperature differences in the vicinity of room temperature. This device, a micro-radiometer, is capable of measuring temperature differences as low as 0.05 degrees at a temperature level of 50 C. Temperature differences were recorded on metal specimens which revealed the presence of artificially introduced defects.

60. McGonnagle, W. J.
NONDESTRUCTIVE TESTING. New York,
McGraw-Hill. 1961, 455p.

Information is included on all aspects of testing and inspection along with the advantages and disadvantages of each method.

61. Moravia, G.
Mechanical and nondestructive testing of welding
processes. RIVISTA ITALIANA DELLA
SALDATURA v. 13, p. 53-59, Mar-Apr 1961.
(In Italian)

Information is included on various destructive and nondestructive methods of testing weldments.

62. Pattee, H. H.
HIGH RESOLUTION CONTACT X-RAY
MICROSCOPY. W. W. Hansen Labs. of
Physics, Stanford Univ., Calif. Technical
rept. no. 1; rept. no. 59, Dec 1961, 36p.
(Contract Nonr-22542, Proj. NR 304-493)
ASTIA AD-269 742.

Experiments on high resolution x-ray recording materials have shown that a great many possibilities exist for producing contact x-ray images which can be enlarged

62. (cont'd) with the electron microscope. Soft x-ray resolution of about 500 angstroms showed that exposure times for such images may be of the order of 10 minutes. The useful field of view may be of the order of 1000 times the minimum resolving distance. The experimental techniques have not yet been reduced to routine practice since almost all the work has been exploratory in nature serving only to demonstrate the possibilities of the general method. Although special instruments such as the microfluoroscope were used in much of the irradiation, it was also demonstrated that a slight modification of the electron microscope which is used to enlarge the x-ray images will also permit its use for the primary irradiation. Throughout the work, an attempt was made to use only those specimen preparation and mounting techniques which are consistent with standard electron microscope procedures.

63. Randall, M.D., Monroe, R.E. and Rieppel, P.J.

METHODS OF EVALUATING WELDED JOINTS.

Defense Metals Information Center, Columbus,

Ohio. DMIC rept. no. 165, 28 Dec 1961, 78p.

(Contract AF 33(616)7747), Proj. 2(8-8975))

ASTIA AD-272 088.

Methods of evaluating welded joints vary throughout the country, depending on the purpose of the evaluation, the welding process, material and thickness involved, and on the needs of the particular industry conducting the evaluation. These varying requirements have led to the development of many different test specimens. New materials and joining processes have led to a sharp increase in the number of specimen types and to confusion in the interpretation of results obtained. An analysis of existing specimens is included to show why so many different specimens are used, and the advantages and limitations of each specimen type. The analysis is a composite of available information in the literature, engineering judgement and experience, and the results of two industry surveys.

64. Schultz, A.W. and Leavitt, W.Z.

THE FEASIBILITY OF USING NEUTRON

RADIOGRAPHY AS A NONDESTRUCTIVE

TESTING TECHNIQUE. Watertown Arsenal

Labs., Mass. Rept. no. WAL TR 142/67;

DA Proj. no. 593-32-007, Dec 1961, 13p.

ASTIA AD-273 279.

64. (cont'd) A preliminary study was conducted to determine the feasibility of using neutron radiography for examining ordnance materials. Depleted uranium and 4140 steel castings in various thicknesses were examined. In addition, a thin section of beryllium, a grasshopper and a cricket were radiographed to illustrate the ability of neutrons to determine defects in low-density materials.

65. Ultrasonics detects faulty bonding.

STEEL v. 144, p. 89, 20 Apr 1959.

A description of an ultrasonic gage which provides a simple, fast, and reliable non-destructive testing method. A quartz transducer is used to detect internal discontinuities in the material being tested.

66. Vettraino, J.T.

PROJECTION MICRORADIOGRAPHY AS

AN INSPECTION MEDIA FOR FERROUS

AND NON-FERROUS METALS. Detroit

Arsenal, Center Line, Mich. Final rept.

Rept. no. 5090, 10 July 1961, 22p. ASTIA

AD-265 138L.